

CLAIMS

I claim:

- [c1] 1. A control surface drive system for moving an aircraft control surface, the system being coupleable to a source of hydraulic fluid, comprising:
- first and second supply lines and a return line coupleable to the source of hydraulic fluid;
 - a plurality of actuator assemblies coupled to the first and second supply lines and to the return line, at least one of the actuator assemblies having:
 - a hydraulic actuator connectable to the aircraft control surface and being movable between first and second positions, the hydraulic actuator configured to receive hydraulic fluid from the first supply line when the hydraulic actuator moves toward the first position, and configured to receive hydraulic fluid from the second supply line when the hydraulic actuator moves toward the second position;
 - a flow blocking member coupled to the first and second supply lines and being movable between an open position and a closed position, with the flow blocking member in the closed position preventing movement of the hydraulic fluid to and from the hydraulic actuator;
 - a flow control assembly connected to the return line and to at least one of the first and second supply lines;
 - a bypass line in fluid communication with the first and second supply lines and positioned to direct hydraulic fluid from one of the first and second supply lines into the other one of the first and second supply lines at a position intermediate the source and the hydraulic actuator when the hydraulic actuator moves toward the first position to

recycle the hydraulic fluid back into the other one of the first and second supply lines; and
a computer controller operatively interconnecting the plurality of actuator assemblies and the flow control assembly.

[c2] 2. The system of claim 1 wherein the at least one of the actuator assemblies includes a position sensor connected to the hydraulic actuator and to the computer controller.

[c3] 3. The system of claim 1 wherein the flow-blocking member is a valve biased toward the closed position.

[c4] 4. The system of claim 1 wherein the flow blocking member is a pressure-sensitive valve.

[c5] 5. The system of claim 1 wherein the at least one of the actuator assemblies has a valve member connected to one of the first and second supply lines and being adjustable to modulate flow of hydraulic fluid to and from the hydraulic actuator.

[c6] 6. The system of claim 1 wherein the flow control assembly is an adjustable valve member configured to control a flow of the hydraulic fluid through the return line and the at least one of the first and second supply lines.

[c7] 7. The system of claim 1, further comprising a valve connected to the bypass line to prevent backflow of the hydraulic fluid.

[c8] 8. The system of claim 1 wherein the first position of the hydraulic actuator is an extended position and the second position is a retracted position, the hydraulic actuator being configured to receive hydraulic fluid from the first

supply line to move toward the extended position, and configured to receive hydraulic fluid from the second supply line to move toward the retracted position.

[c9] 9. The system of claim 1, further comprising an alternate mode power system coupled to the plurality of actuator assemblies and dedicated for operation of the plurality of actuator assemblies.

[c10] 10. The system of claim 1, further comprising an alternate mode power system having a hydraulic line connected to at least one of the first and second supply lines, and a pump connected to the hydraulic line, the pump being positioned to direct hydraulic fluid to the plurality of actuator assemblies.

[c11] 11. The system of claim 10 wherein the alternate mode power system includes the flow control member connected to the hydraulic line and operatively coupled to the control computer.

[c12] 12. The system of claim 10 wherein the pump is an AC motor pump, and the alternate mode power system includes a motor-operated shutoff valve connected to the hydraulic line.

[c13] 13. The system of claim 1 wherein the flow control assembly includes a valve movable between a first valve position for movement of the hydraulic actuator toward the first position, a second valve position for movement of the hydraulic actuator toward the second position, and a third valve position that restricts the hydraulic actuator from moving.

[c14] 14. The system of claim 1 wherein the control computer is a flight control computer.

[c15]

15. An aircraft system, comprising:
- first and second control surfaces;
 - a source of hydraulic fluid;
 - a first control system coupled to the first control surface and a second control system coupled to the second control surface, each of the first and second control systems comprising:
 - first and second supply lines coupled to the source of hydraulic fluid;
 - a return line coupled to the source of hydraulic fluid;
 - a hydraulic actuator connected to at least one of the first and second aircraft control surfaces, the hydraulic actuator being movable between first and second positions, the hydraulic actuator configured to receive hydraulic fluid from the first supply line when the hydraulic actuator moves toward the first position, and configured to receive hydraulic fluid from the second supply line when the hydraulic actuator moves toward the second position;
 - a flow blocking member coupled to the first and second supply lines and being movable between an open position and a closed position, the flow blocking member in the closed position prevents movement of the hydraulic fluid to and from the hydraulic actuator;
 - a flow control assembly connected to the return line and to at least one of the first and second supply lines;
 - a bypass line in fluid communication with the first and second supply lines and positioned to direct hydraulic fluid from one of the first and second supply lines into the other one of the first and second supply lines upstream of the hydraulic actuator when the hydraulic actuator moves toward the first position to recycle the hydraulic fluid back into the other one of the first and second supply lines; and

a computer controller operatively interconnecting the first and second control systems.

[c16] 16. The aircraft system of claim 15 wherein the first aircraft control surface is a first wing flap, and the second aircraft control surface is a second wing flap.

[c17] 17. The aircraft system of claim 15 wherein each first and second control system further comprises a position sensor coupled to the hydraulic actuator and to the computer controller.

[c18] 18. The aircraft system of claim 15 wherein the flow blocking member includes a pressure-sensitive valve.

[c19] 19. The aircraft system of claim 15 wherein the at least one of the first and second control systems further includes a valve member connected to one of the first and second supply lines and being adjustable to modulate flow of hydraulic fluid to and from the hydraulic actuator.

[c20] 20. The aircraft system of claim 15 wherein the flow control assembly is an adjustable valve member configured to control a flow of the hydraulic fluid through the return line and the at least one of the first and second supply lines.

[c21] 21. The aircraft system of claim 15 wherein the first position of the hydraulic actuator is an extended position and the second position is a retracted position, the hydraulic actuator being configured to receive hydraulic fluid from the first supply line to move toward the extended position, and configured to receive hydraulic fluid from the second supply line to move toward the retracted position.

[c22] 22. The aircraft system of claim 15 wherein at least one of the first and second control systems further comprises a power system coupled to the hydraulic actuator and dedicated for operation with the at least one of the first and second control systems.

[c23] 23. The aircraft system of claim 22 wherein the power system includes a hydraulic line connected to at least one of the first and second supply lines, and a pump connected to the hydraulic line, the pump being positioned to direct hydraulic fluid to the hydraulic actuator.

[c24] 24. The aircraft system of claim 22 wherein the power system includes the flow control member connected to the hydraulic line and operatively coupled to the control computer.

[c25] 25. The aircraft system of claim 15 wherein the flow control assembly includes a valve movable between a first valve position for movement of the hydraulic actuator toward the first position, a second valve position for movement of the hydraulic actuator toward the second position, and a third valve position that restricts the hydraulic actuator from moving.

[c26] 26. The aircraft system of claim 15 wherein the flow blocking member controller is a pressure-sensitive valve biased toward a closed position.

[c27] 27. The aircraft system of claim 15, further comprising a fuselage and a wing connected to the fuselage, at least one of the first and second control surfaces being connected to the wing.

[c28] 28. An aircraft system, comprising:
first and second aircraft control surfaces;
a source of hydraulic fluid;

a first control system coupled to the first aircraft control surface and a second control system coupled to the second aircraft control surface, each of the first and second control systems comprising:

- first and second supply lines coupled to the source of hydraulic fluid;
- a return line coupled to the source of hydraulic fluid;
- a hydraulic actuator connected to at least one of the first and second aircraft control surfaces, the hydraulic actuator having a first port in fluid communication with the first supply line and a second port isolated from the first port and in fluid communication with the second supply line;
- a first flow controller coupled to the first and second supply lines and movable between a first position that allows hydraulic fluid to move to and from the hydraulic actuator and a second position that prevents movement of the hydraulic fluid to and from the hydraulic actuator to retain the hydraulic actuator in a fixed position;
- a second flow controller coupled to at least the first and second supply lines and configured to control the flow of hydraulic fluid to and from at least one of the first and second ports;
- a flow control assembly connected to the first supply line and to the return line, the flow control assembly being configured to control the flow of hydraulic fluid in one direction from the first supply line to at least one of the hydraulic actuators and to control the flow of hydraulic fluid in another direction from the hydraulic actuator to the return line; and
- a bypass line in fluid communication with the first and second supply lines in a position intermediate the source and the hydraulic actuator and positioned to provide hydraulic fluid from the second supply line into the first supply line upstream of the hydraulic actuator; and

a flight control computer operatively interconnecting the first and second control systems.

[c29] 29. The aircraft system of claim 28 wherein the first aircraft control surface is a first wing flap, and the second aircraft control surface is a second wing flap.

[c30] 30. The aircraft system of claim 28, further comprising a first dedicated alternate mode power system connected to the first control system and a second dedicated alternate mode power system connected to the second control system.

[c31] 31. The aircraft system of claim 28, further comprising a dedicated backup power system connected to the first control system and being independent of the second control system, the backup power system including a hydraulic line connected to the second supply line, and a pump connected to the hydraulic line and configured to pump hydraulic fluid to the hydraulic actuator.

[c32] 32. The aircraft system of claim 28 wherein the flow control assembly is a blocking valve movable between an open and a closed position.

[c33] 33. The aircraft system of claim 28 wherein the second flow controller is connected to the second supply line.

[c34] 34. The aircraft system of claim 28 wherein the hydraulic actuator is movable between extended and retracted positions, the first supply line configured to provide the hydraulic fluid to move the hydraulic actuator toward the extended position and the second supply line configured to provide the hydraulic fluid to move the hydraulic actuator toward the retracted position.

[c35] 35. The aircraft system of claim 28 wherein the flow control valve assembly includes a valve movable between a first position that controls a flow of hydraulic fluid through the first supply line, a second position that controls a flow of hydraulic fluid through the return line, and a third position that restricts flow of the hydraulic fluid through the first supply line and through the return line.

[c36] 36. The aircraft system of claim 28, further comprising a fuselage and a wing connected to the fuselage, at least one of the first and second control surfaces being connected to the wing.

[c37] 37. An actuator control system for controlling first and second control portions, the system being coupleable to a source of fluid, comprising:

first and second supply lines and a return line coupleable to the source of fluid;

a fluid-driven actuator connected to at least one of the first and second control portions, the fluid-driven actuator in fluid communication with the first and second supply lines;

a flow control assembly connected to the first supply line and to the return line and configured to control the flow of fluid in one direction from the first supply line to the fluid-driven actuators and to control the flow of fluid in another direction from the fluid-driven actuator to the return line; and

a bypass line in fluid communication with the first and second supply lines and positioned to provide fluid from the second supply line into the first supply line at a position intermediate the source and the fluid-driven actuator.

[c38] 38. The system of claim 37, further comprising a flow controller connected to the first and second supply lines and being movable from a first

position that allows movement of the fluid-driven actuator and a second position that restricts movement of the fluid-driven actuator.

[c39] 39. The system of claim 38 wherein the flow controller is a blocking valve and the first position is an open position and the second position is a closed position.

[c40] 40. The system of claim 37 wherein the fluid-driven actuator is a hydraulic actuator.

[c41] 41. The system of claim 37, further comprising a dedicated power system having a fluid line connected to at least one of the first and second supply lines, and a pump connected to the fluid line and configured to pump fluid to the fluid-driven actuator.

[c42] 42. The system of claim 37 wherein the fluid-driven actuator is movable between extended and retracted positions, the first supply line being configured to provide the fluid to move the fluid-driven actuator toward the extended position and the second supply line being configured to provide the fluid to move the fluid-driven actuator toward the retracted position.

[c43] 43. The system of claim 37 wherein the flow control assembly includes a valve movable between a first position that controls a flow of fluid through the first supply line, a second position that controls a flow of fluid through the return line, and a third position that restricts flow through the first supply line and through the return line.

[c44] 44. A method of making a control surface drive system, comprising:
 connecting first and second supply lines and a return line to a source of
 fluid;

connecting a plurality of fluid-driven actuator assemblies to the first and second supply lines and to the return line;
connecting the fluid-driven actuator assemblies to at least one control surface;
connecting a flow control assembly to the return line and to at least one of the first and second supply lines; and
connecting a bypass line to the first and second supply lines in a position to direct fluid from one of the first and second supply lines into the other one of the first and second supply lines at a position intermediate the source of fluid and at least one of the fluid-driven actuators when the at least one of the fluid-driven actuators moves toward the first position to recycle the fluid back into the other one of the first and second supply lines.

[c45] 45. The method of claim 44, further comprising connecting a flow blocking member to the first and second supply lines, the flow blocking member being movable between an open position and a closed position, the flow blocking member in the closed position prevents movement of the fluid to and from at least one of the fluid-driven actuators.

[c46] 46. The method of claim 44, further comprising connecting a computer controller to the plurality of actuator assemblies and to the flow control assembly, the computer controller operatively interconnecting the plurality of fluid-driven actuator assemblies.

[c47] 47. The method of claim 44 wherein the fluid-driven actuator assemblies include a position sensor, and further comprising connecting the position sensor to the control computer.

[c48] 48. The method of claim 44, further comprising biasing the flow-blocking member toward the closed position.

[c49] 49. The method of claim 44, further comprising connecting an alternate mode power system to the plurality of fluid-driven actuator assemblies with the alternate mode power system being dedicated for operation of the plurality of fluid-driven actuator assemblies.

[c50] 50. The method of claim 44, further comprising connecting a fluid line to at least one of the first and second supply lines, and connecting a backup pump to the fluid line, the backup pump being positioned to direct fluid to the plurality of fluid-driven actuator assemblies.